Entergy

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

John A. Dent, Jr.
Site Vice President

March 31, 2014

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

SUBJECT: Entergy's Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident

Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

LETTER NUMBER 2.14.026

REFERENCES:

1. NRC Letter "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", dated March 12, 2012 (ML12053A340)
2. NEI Letter to NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations", dated April 9, 2013 (ML13101A345)
3. Entergy Letter to NRC, "Entergy's Response to NRC Request For Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – 1.5 Year Response for CEUS Sites", dated September 12, 2013 (PNPS Letter 2.13.071)
4. NRC Letter, "Electric Power Research Institute Final Draft Report XXXXXX, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Near-Term Task Force Recommendation 2.1: Seismic, as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations", dated May 7, 2013 (ML13106A331)
5. Entergy Letter to NRC "Entergy's Supplemental Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – 1.5 Year Response for CEUS Sites", dated March 10, 2014 (PNPS Letter 2.14.019)

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6. EPRI Report 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic", dated November, 2012 (ML12333A170)

7. NRC Letter, "Endorsement of Electric Power Research Institute Final Draft Report 1025287, Seismic Evaluation Guidance", dated February 15, 2013 (ML12319A074)

8. NRC Letter "Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", dated February 20, 2014 (ML14030A046)

Dear Sir or Madam:

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee located in the Central and Eastern United States (CEUS) to submit a Seismic Hazard Evaluation within 1.5 years from the date of Reference 1.

In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by September 12, 2013 which was completed via Reference 3, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 4.

On March 10, 2014, Pilgrim Nuclear Power Station (PNPS) submitted Reference 5 to NRC with a supplemental response to the September 12, 2013 letter. The attachment to Reference 5 contained revised information regarding site specific soil data to be used as input to the seismic hazard evaluation attached to this letter.

Reference 6 contains industry guidance and detailed information to be included in the Seismic Hazard and Screening Report submittals. NRC endorsed this industry guidance in Reference 7.

Reference 8 contains NRC supplemental information to be included in the Seismic Hazard and Screening Report submittals.

The attached Seismic Hazard and Screening Report for PNPS provides the information described in Section 4 of Reference 6 in accordance with the schedule identified in Reference 2.

Should you have any questions concerning the content of this letter, please contact Mr. Joseph R. Lynch, Manager, Regulatory Assurance at (508) 830-8403.

This letter contains no new regulatory commitments. I declare under penalty of perjury that the foregoing is true and correct; executed on March 31, 2014.

Sincerely,

John A. Dent Jr.
Site Vice President
JAD/rmb

Attachment: Seismic Hazard and Screening Report for Pilgrim Nuclear Power Station

cc: Mr. William M. Dean
Regional Administrator, Region 1
U.S. Nuclear Regulatory Commission
2100 Renaissance Boulevard, Suite 100
King of Prussia, PA 19406-1415

U. S. Nuclear Regulatory Commission
Director, Office of Nuclear Reactor Regulation
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Ms. Nadiyah Morgan, Project Manager
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Stop O-8C2A
Washington, DC 20555

Mr. John Giarrusso Jr.
Planning, Preparedness & Nuclear Section Chief
Mass. Emergency Management Agency
400 Worcester Road
Framingham, MA 01702

U. S. Nuclear Regulatory Commission
ATTN: Robert J. Fretz Jr.
Mail Stop OWFN/4A15A
11555 Rockville Pike
Rockville, MD 20852-2378

U. S. Nuclear Regulatory Commission
ATTN: Robert L. Dennig
Mail Stop OWFN/10E1
11555 Rockville Pike
Rockville, MD 20852-2378

NRC Senior Resident Inspector
Pilgrim Nuclear Power Station

ATTACHMENT to

PNPS Letter 2.14.026

SEISMIC HAZARD AND SCREENING REPORT FOR PILGRIM NUCLEAR POWER STATION

NOTE:
This Attachment was developed for Pilgrim Nuclear Power Station (PNPS) by AREVA NP Inc. via Document 51-9218839-004 using the industry standard submittal template distributed by the Nuclear Energy Institute (NEI).

The new PNPS site specific seismic hazard information was developed by Electric Power Research Institute (EPRI) and their contractor Lettis Consultants International Inc. as documented in "Pilgrim Seismic Hazard and Screening Report Rev 1" received via EPRI Letter RSM-022714-064, dated 2/27/14. The EPRI/Lettis report has been incorporated directly into AREVA 51-9218839-004 (this attachment).

The AREVA and EPRI/Lettis documents are captured in PNPS plant records by Engineering Change EC49833.

Table of Contents

1.0 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) established a Near-Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) (U.S. NRC, 2012) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants. The 50.54(f) letter (U.S. NRC, 2012) requests that licensees and holders of construction permits under 10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment, the NRC staff will determine whether additional regulatory actions are necessary.

This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter (U.S. NRC, 2012) pertaining to NTTF Recommendation 2.1 for the Pilgrim Nuclear Power Station (PNPS), located in Plymouth County, Massachusetts. In providing this information, Entergy followed the guidance provided in the *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (EPRI, 2013a). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (EPRI, 2013c), has been developed as the process for evaluating critical plant equipment as an interim action to demonstrate additional plant safety margin prior to performing the complete plant seismic risk evaluations.

The original geologic and seismic siting investigations for PNPS were performed prior to issuance of 10 CFR 100 Appendix A. PNPS was issued a low power Operating License on June 8, 1972 following issuance of a Construction Permit on August 26, 1968. During the construction licensing process, the unit was evaluated against the original 70 criteria proposed in July, 1967 by the Atomic Energy Commission (AEC). By Staff Requirements Memorandum, NRC Office of the Secretary of the Commission SECY-92-223, issued on September 18, 1992, the Commission approved the staff proposal to not apply the General Design Criteria (GDC) to plants with construction permits issued prior to May 21, 1971. At the time of promulgation of Appendix A to 10 CFR 50 in 1971, the Commission stressed that the GDCs were not new requirements and were promulgated to more clearly articulate the licensing requirements and practices in effect at that time. While compliance with the intent of the GDC is important, each plant licensed before the GDC were formally adopted was evaluated on a plant-specific basis, determined to be safe, and licensed by the Commission (Entergy, 2005a). The AEC Preliminary

Criterion 2 applies to the design of SSCs with respect to forces that may be imposed by natural phenomena including earthquakes. The Safe Shutdown Earthquake (SSE) developed for PNPS was demonstrated to be in conformance with AEC Criterion 2 as documented in "Design Basis Document for Seismic Design" (Entergy 2005a) and FSAR Sections 2.5.3 and Appendix F.2.1 (Entergy, 2013a).

In response to the 50.54(f) letter (U.S. NRC, 2012) and following the guidance provided in the SPID (EPRI, 2013a), a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. Based on the results of the screening evaluation, Pilgrim screens-in for a risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency Confirmation.

2.0 Seismic Hazard Reevaluation

Pilgrim Nuclear Power Station is located in the town of Plymouth, Plymouth County, Massachusetts which is approximately 25 miles southeast of Brockton, Massachusetts, and adjacent to the Cape Cod Bay. The Pilgrim site is located on the shoreline of Cape Cod Bay near Rocky Point in Plymouth, Massachusetts. The rocks and sediments in the region range in age from Precambrian to Recent. Pleistocene glacial till and outwash of variable thickness generally mantles the region. The site is within the deeply-eroded Appalachian Mountain System and since Precambrian time, the region has had several episodes of folding, faulting, and igneous intrusion with associated metamorphism of pre-existing rocks. Glaciation and the Atlantic Ocean's rise to its present level have also modified the region's topography. There are six regional structural provinces but there are three basins which characterize the geology of eastern Massachusetts: Narragansett, Boston, and Newbury Basins. (Entergy, 2013a)

The study of the seismic history of the area indicates that, very probably, the site will not experience any major earthquakes during the life of the station. The following three earthquakes have been determined as the most significant with respect to the site (Entergy, 2013a):

1. Southeastern Massachusetts, 1925, intensity V on the Modified Mercalli Intensity Scale of 1931, located about 17 miles southwest of the site
2. Southeastern Massachusetts, 1847, intensity VI on the Modified Mercalli Intensity Scale of 1931, located about 30 miles west of the site
3. Cape Ann area, a series from the early 1600s through recent, maximum intensity VIII on the Modified Mercalli Intensity Scale of 1931, located about 55 to 60 miles north of the site

The ground acceleration at the site due to the recurrence of a shock similar to any of the above earthquakes would be less than 0.05g. (Entergy, 2013a)

The SSE is generally considered to be a recurrence of the largest earthquake in the region at the closest epicentral distance which is consistent with the geologic structure. The Cape Ann series of earthquakes appear to be the most severe earthquakes which need to be considered for the plant design. The occurrence of an earthquake as large as the maximum Cape Ann sequence (VIII on the Modified Mercalli Intensity Scale of 1931), with its epicenter at the closest approach of faulting associated with the Boston and Narragansett Basins (17 miles west of the site) is the most critical situation for the site. Horizontal ground acceleration at estimated foundation depths (within the compact glacial deposits) due to the above earthquake could be about 0.15g. (Entergy, 2013a)

Therefore, the station Class I structures and systems have been designed for horizontal ground accelerations of 0.08g (Operating Basis Earthquake) and 0.15g (SSE). (Entergy, 2013a)

2.1 Regional and Local Geology

The exposed rocks and sediments in the region range in age from Precambrian to Recent. Precambrian, Cambrian, Ordovician, Silurian, and Devonian rocks, consisting of metamorphics, igneous intrusives and extrusives, and a few small areas of relatively unmetamorphosed sedimentary rocks, predominate in the region. (Entergy, 2013a)

Carboniferous and Triassic rocks are presently exposed in, and generally restricted to, some faulted basins in the region. Sediments were accumulated in these basins primarily under non-marine conditions, and are preserved due to subsidence and down faulting within the basins. Carboniferous rocks are known to occur in the Boston and Narragansett Basins and in Nova Scotia and New Brunswick. Triassic rock occurs in the Connecticut Valley and in the south of Nova Scotia. Igneous intrusives of Permian Carboniferous and Triassic Jurassic Age are also exposed in the region. (Entergy, 2013a)

Relatively undisturbed Cretaceous, Eocene, and Miocene marine sedimentary strata are known to occur in isolated locations along the present coast and offshore. In places, these sediments were deformed by the glaciers which subsequently advanced across the region. The contortion of these sediments by the movement of the great thickness of glacial ice is particularly evident in exposures on Martha's Vineyard. (Entergy, 2013a)

Pleistocene glacial deposits of greatly varying thickness, consisting primarily of till and outwash, generally mantle the region. Isolated bedrock outcrops occur west of a line between Kingston, Massachusetts and Buzzard's Bay. This line passes about 7 miles west of the site. East of this line, the bedrock is usually completely mantled by the glacial deposits. The existence of glacial deposits covering the bedrock and the lack of Tertiary and Mesozoic Rocks make structural interpretation and dating of geologic events difficult and in some cases questionable. (Entergy, 2013a)

This site is located within the Appalachian Mountain System which extends from Newfoundland to Alabama. The Appalachian Mountain System in the New England area extends from eastern New York State to the edge of the continental shelf. This mountain system has been deeply eroded to its present elevation. (Entergy, 2013a)

The geologic history of the New England portion of this Mountain system can be separated into four major time periods. (Entergy, 2013a)

Not much is known about the Precambrian period in the New England region since the rocks of this age have been greatly altered. However, during this period several episodes of mountain building took place to the northwest, in the Canadian Shield area. (Entergy, 2013a)

During the early Paleozoic, two major episodes of folding, faulting, and igneous intrusion, with associated metamorphism of preexisting rocks, occurred. These major tectonic episodes took place during the Ordovician, 425 million or more years ago and the Devonian, 350 million or more years ago. These major episodes formed the backbone of the Appalachian Mountain System in the New England region. (Entergy, 2013a)

During late Paleozoic and early Mesozoic time, two less intense but important tectonic episodes occurred. This activity took place during the Permian to Carboniferous, 230 million or more years ago, and during the Jurassic to Triassic, 135 million or more years ago. These episodes concluded the major tectonic sequence of events which formed the Appalachian System. The major events of these two tectonic episodes were: the thrust faulting of the western part of the region, the formation of the Carboniferous and Triassic basins; and the emplacement of the final igneous intrusives (the Permo-Carboniferous granites, and the White Mountains Magma Series). (Entergy, 2013a)

Since the Cretaceous the region has not experienced any strong tectonic activity. The Cretaceous and Tertiary sediments deposited along the flank of the continental mass under maring conditions are, therefore, relatively undisturbed. (Entergy, 2013a)

During the Pleistocene, glaciers advanced several times across the entire region and greatly modified the existing topography. Glacial erosion removed most of the overburden soils and some of the bedrock. The glaciers also deposited large amounts of material in the form of moraines and outwash plains. Cape Cod and the islands south of New England are largely terminal moraines with associated outwash plains. The final retreat of the glaciers from the rock took place approximately 10 to 15 thousand years ago. (Entergy, 2013a)

The irregular topography consisting of moraines, outwash plains and kettles with generally unintegrated drainage, has been modified since the retreat of the glaciers by the rise of the Atlantic Ocean to its present level and by the effect of rain and wind. The modifications of the topography consisted of coastal retreat, the introduction of better integrated drainage and the gradual filling of the swampy areas in the kettle depressions. (Entergy, 2013a)

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter (U.S. NRC, 2012) and following the guidance in the SPID (EPRI, 2013a), a probabilistic seismic hazard analysis (PSHA) was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (CEUS-SSC, 2012) together with the updated Electric Power Research Institute (EPRI) Ground-Motion Model (GMM) for the Central and Eastern United States (CEUS) (EPRI, 2013b). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter (U.S. NRC, 2012). (EPRI, 2014)

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around Pilgrim were included. This distance exceeds the 200 mile (320 km) recommendation contained in Reg. Guide 1.208 (U.S. NRC, 2007) and was chosen for completeness. Background sources included in this site analysis are the following (EPRI, 2014):

1. Atlantic Highly Extended Crust (AHEX)
2. Extended Continental Crust—Atlantic Margin (ECC_AM)
3. Great Meteor Hotspot (GMH)
4. Mesozoic and younger extended prior – narrow (MESE-N)
5. Mesozoic and younger extended prior – wide (MESE-W)
6. Midcontinent-Craton alternative A (MIDC_A)
7. Midcontinent-Craton alternative B (MIDC_B)
8. Midcontinent-Craton alternative C (MIDC_C)
9. Midcontinent-Craton alternative D (MIDC_D)
10. Northern Appalachians (NAP)
11. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
12. Non-Mesozoic and younger extended prior – wide (NMESE-W)
13. Paleozoic Extended Crust narrow (PEZ_N)
14. Paleozoic Extended Crust wide (PEZ_W)
15. St. Lawrence Rift, including the Ottawa and Saguenay grabens (SLR)
16. Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources, in NUREG-2115 (CEUS-SSC, 2012) modeled for the CEUS-SSC, the following sources lie within 1,000 km of the site and were included in the analysis (EPRI, 2014):

1. Charlevoix

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM was used. (EPRI, 2014)

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID (EPRI, 2013a), base rock seismic hazard curves are not provided as the site amplification approach referred to as Method 3 has been used. (EPRI, 2014)

2.3 Site Response Evaluation

Following the guidance contained in Seismic Enclosure 1 of the 50.54(f) request for information (U.S. NRC, 2012) and in the SPID (EPRI, 2013a) for nuclear power plant sites that are not founded on hard-rock (defined as 2.83 km/sec), a site response analysis was performed for PNPS. (EPRI, 2014)

2.3.1 Description of Subsurface Material

The Pilgrim Nuclear Power Station is located on the shore of Cape Cod Bay in Plymouth, Massachusetts. The information used to create the site geologic profile at PNPS is shown in Table 2.3.2-1 was obtained from the FSAR (Entergy, 2013a). As indicated in Table 2.3.2-1, the SSE Control Point is at an elevation of -26 ft (-8 m) MSL. The PNPS consists of about 42 ft (13 m) of glacial outwash overlying about 6 ft (2 m) of weathered bedrock with hard metamorphic bedrock below. Depth to hard basement rock (shear-wave velocity of at least 9,300 ft/s (2,830 m/s)) was specified at a depth below the SSE of 48 ft (15 m). (EPRI, 2014)

The following description of the site properties is taken from site-specific information in the FSAR (Entergy, 2013a):

> PNPS site is located on the shoreline of Cape Cod Bay near Rocky Point in Plymouth, Massachusetts. The rocks and sediments in the region range in age from Precambrian to Recent. Pleistocene glacial till and outwash of variable thickness generally mantles the region. The site is within the deeply eroded Appalachian Mountain System and since Precambrian time, the region has had several episodes of folding, faulting, and igneous intrusion with associated metamorphism of pre-existing rocks. Glaciation and the Atlantic Ocean's rise to its present level have also modified the region's topography.
>
> The site is located in a depression from 14 to 32 ft above mean sea level (MSL) on the northeast side of a glacial ridge. Bedrock at the site is about 64 ft below MSL and is topped by glacial and recent deposits. Boulders are also scattered throughout the overburden soils. No known faults at or near the site were revealed.
>
> The bedrock is part of the Dedham granodiorite group. Five seismic refraction traverses were made in the area of the plant site. These traverses indicate an irregular bedrock surface from 30 to 90 ft below MSL. Bedrock was encountered in two borings in the site area at 64 ft below MSL. The bedrock, as indicated by the cores, is slightly weathered to a depth of 6 ft, but competent with infrequent joints and fractures below

this depth.

The subsurface investigations in the site area indicated about 65 to 115 ft of glacial and recent deposits overlie bedrock. An upper discontinuous, erratic zone of sandy silts, and silty and clayey sands up to about 20 ft thick, often overlain by a thin stratum of sand and gravel, was disclosed. The lower glacial zone, which extends to bedrock, consists of poorly graded to well graded sands with varying amounts of gravel and cobbles. Pockets of silty sand were detected in this stratum. Boulders are scattered throughout the overburden soils and an approximately 10 ft thick, apparently discontinuous boulder zone overlies bedrock. The borings encountered boulders which average about 2 ft in diameter and varied to 6 ft in diameter. Larger boulders up to 20 or 30 ft are occasionally observed at the site. The materials below about 35 ft in depth are compact to dense.

The following description of the site properties is taken from additional site-specific information in the FSAR as well as other noted references (Entergy, 2013a):

PNPS FSAR Section 2.5.2.4.2 includes a description of the site bedrock. The bedrock consists of Dedham granodiorite. It is described as "slightly weathered to a depth of 6 ft, but competent with infrequent joints and fractures below this depth".

The shear wave velocity information contained in Table 2.3.2-1 of this report was developed for PNPS by GEI Consultants (GEI Consultants, 2012). The information sources used by GEI included PNPS approved safety-related calculation C15.0.3306 which documents a bedrock shear wave velocity of 10,500 fps. However, at the time that the original GEI work was performed, they did not have access to the reference material that supported the 10,500 fps value. GEI therefore assigned a lower value of 6000 fps for all of the bedrock based on other information sources. This approach did not reflect the transition from the upper 6' layer of weathered rock to the competent granodiorite bedrock below."

The site specific testing information that supports the 10,500 fps is contained in the Engineering Seismology Report developed by Dames & Moore which is attached to PNPS Design & Analysis Report (Entergy, 1967). This information was subsequently provided to GEI for their review. Based on their review, GEI has agreed that the originally specified 6000 fps shear wave velocity is appropriate for the upper 6' weathered layer and that the 10,500 fps is appropriate for the competent granodiorite below (GEI Consultants, 2014).

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Table 2.3.2-1 shows the recommended shear-wave velocities along with depths, elevations unit weights and corresponding stratigraphy. The SSE control point is at a depth of 48 ft (15 m) within glacial outwash with an estimated shear-wave velocity of 1,800 ft/s (549 m/s). The soil overlays a 6 ft (2 m) thick layer of weathered granodiorite with a shear-wave velocity of 6,000 ft/s (1,829 m/s). (EPRI, 2014)

Shear-wave velocity measurements consist of both refraction and cross-hole surveys with values consistent with more recent measurements at the nearby Independent Spent Fuel Storage Installation (ISFSI) facility. As a result, uncertainty for the shallow glacial outwash material and weathered bedrock was taken as 1.25. The scale factors of 1.25 reflect $\sigma_{\ln}$ of about 0.20 based on the SPID (EPRI, 2013a) 10^{th} and 90^{th} fractiles which implies a 1.28 scale factor on σ_{μ}. (EPRI, 2014)

Table 2.3.2-1. Summary of Geotechnical Profile Data for PNPS. (EPRI, 2014)

Depth Range (feet)	Elevation MSL	Soil/Rock Description	Shear Wave Velocity (fps)
0	+22 ft	Surface Grade	-
0 to 20	+22 ft to +2 ft	Compacted Fill	675
20 to 48	+2 ft to -26 ft	Compacted Fill	900
48	-26 ft	Reactor Building Foundation (SSE control point)	-
48 to 90	-26 ft to -68 ft	Glacial Outwash	1,800
90 to 96	-68 ft to -74 ft	Weathered Upper Bedrock Layer	6,000
96+	-74 ft and below	Competent Granodiorite Bedrock	10,500

Notes: Reference Page 5 of GEI Report and additional GEI correspondence

Table 2.3.2-1a: Unit Weight

Soil / Rock	Total Unit Weight Above Water Table (pcf)	Total Unit Weight Below Water Table (pcf)
Compacted Fill	126	137
Glacial Outwash	N/A	129
Bedrock	N/A	168

Notes: Reference Page 2 of GEI Report
Groundwater elevation +1 ft to +6 ft MSL (depth 16 to 21 ft) at Reactor Building

Using the shear-wave velocities specified in Table 2.3.2-1 three base-case profiles were developed using the scale factors of 1.25 for the glacial outwash and weathered rock. The specified shear-wave velocities were taken as the mean or best estimate base-case profile (P1) with lower and upper range base-cases profiles P2 and P3 respectively. All three profiles extend to a depth (below the SSE) of about 48 ft (14.6 m), randomized ±10 ft (±3 m). Profile P3, the stiffest profile was taken to encounter hard reference rock at a depth of 42 ft. The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-2. The depth randomization reflects ± 20% of the depth and was included to provide a realistic broadening of the fundamental resonance at shallow sites in addition to reflect actual random variations in depth to basement shear-wave velocities across a footprint. (EPRI, 2014)

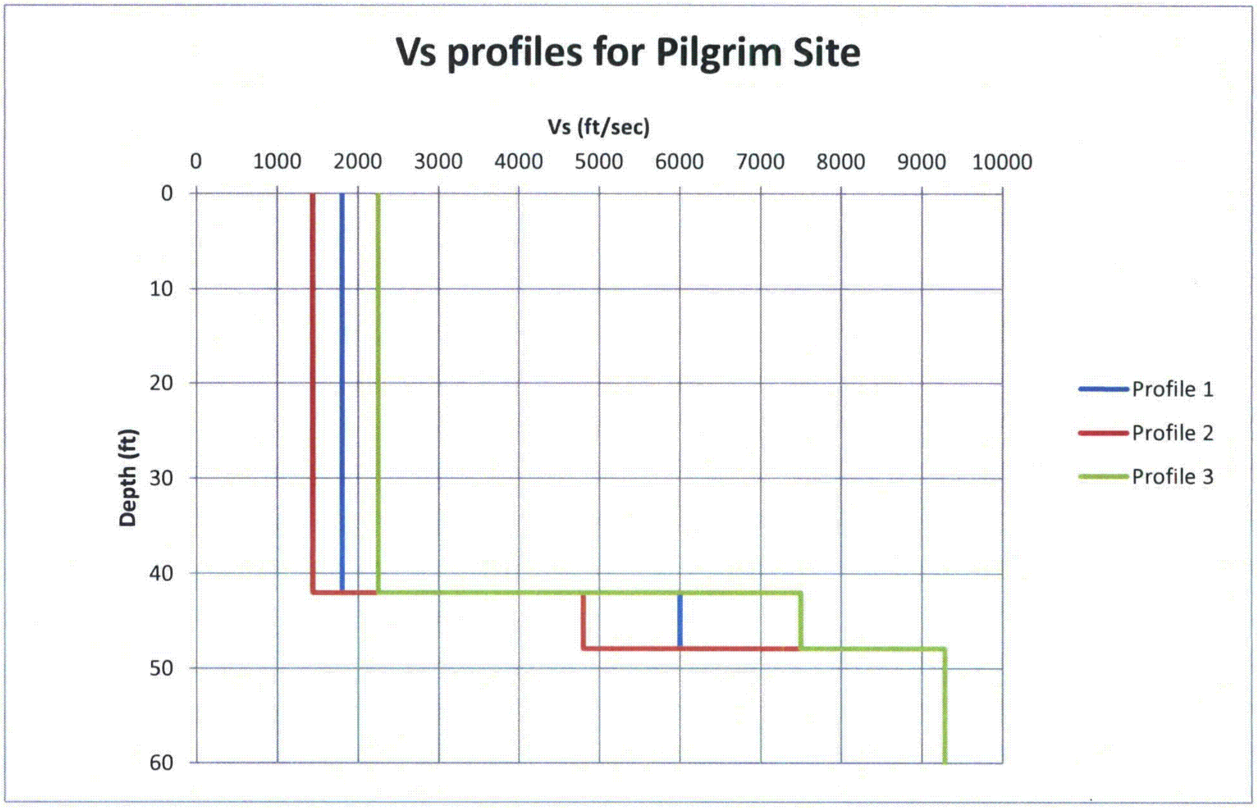


Figure 2.3.2-1. Shear-wave velocity profiles for PNPS site. (EPRI, 2014)

Table 2.3.2-2. Layer thicknesses, depths, and shear-wave velocities (Vs) for 3 profiles, PNPS. site. (EPRI, 2014)

Profile 1			Profile 2			Profile 3		
Thickness (ft)	depth (ft)	Vs(ft/s)	Thickness (ft)	depth (ft)	Vs(ft/s)	Thickness (ft)	depth (ft)	Vs(ft/s)
	0	1,800		0	1,440		0	2,250
5.0	5.0	1,800	5.0	5.0	1,440	5.0	5.0	2,250
5.0	10.0	1,800	5.0	10.0	1,440	5.0	10.0	2,250
5.0	15.0	1,800	5.0	15.0	1,440	5.0	15.0	2,250
5.0	20.0	1,800	5.0	20.0	1,440	5.0	20.0	2,250
2.0	22.0	1,800	2.0	22.0	1,440	2.0	22.0	2,250
5.0	27.0	1,800	5.0	27.0	1,440	5.0	27.0	2,250
5.0	32.0	1,800	5.0	32.0	1,440	5.0	32.0	2,250
5.0	37.0	1,800	5.0	37.0	1,440	5.0	37.0	2,250
5.0	42.0	1,800	5.0	42.0	1,440	5.0	42.0	2,250
5.9	47.9	6,000	5.9	47.9	4,800	5.9	47.9	7,500
3,280.8	3,328.7	9,285	3,280.8	3,328.7	9,285	3,280.8	3,328.7	9,285

2.3.2.1 Shear Modulus and Damping Curves

No site-specific nonlinear dynamic material properties were available for the PNPS soils and firm rock. The soil material over the upper 42 ft (12.8 m) was assumed to have behavior that could be modeled with either EPRI cohesionless soil or Peninsular Range (PR) G/G_{max} and hysteretic damping curves while the firm rock was assumed to reflect either EPRI firm rock curves or linear response (EPRI, 2013a). Consistent with the SPID (EPRI, 2013a), the EPRI soil and firm rock curves (model M1) were considered to be appropriate to represent the more nonlinear response likely to occur in the materials at this site. The PR curves for soils combined with linear analysis for firm rock (model M2) (EPRI, 2013a) was assumed to represent an equally plausible alternative more linear response across loading level. (EPRI, 2014)

2.3.2.2 Kappa

Base-case kappa estimates were determined using Section B-5.1.3.1 of the SPID (EPRI, 2013a) for sites with less than 3,000 ft (1,000 m) of soil. For soil sites with depths less than 3,000 ft (1,000 m) to hard rock, a mean base-case kappa may be estimated based on total soil and firm rock thickness of 48 ft (14.6 m) with the addition of the hard basement rock value of 0.006 s (EPRI, 2013a). For base-case profiles P1, P2, and P3 the kappa contributions from the profiles was 0.001 s, 0.001 s, and 0.001 s respectively. The total kappa values, after adding the hard reference rock value of 0.006 s, were 0.007 s, 0.007 s, and 0.007 s respectively (Table 2.3.2-3). The kappa at this shallow site is dominated by the hard rock kappa. Epistemic uncertainty in profile damping (kappa) was considered to be accommodated at design loading levels by the range of damping (kappa) provided by the multiple (2) sets of G/G_{max} and hysteretic damping curves. (EPRI, 2014)

Table 2.3.2-3. Kappa Values and Weights Used for Site Response Analyses. (EPRI, 2014)

Velocity Profile	Kappa(s)
P1	0.007
P2	0.007
P3	0.007
	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

2.3.3 Randomization of Base Case Profiles

To account for the aleatory variability in dynamic material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the assumed shear-wave velocity profiles has been incorporated in the site response calculations. For the PNPS site, random shear wave velocity profiles were developed from the base case profiles shown in Figure 2.3.2-1. Consistent with the discussion in Appendix B of the SPID (EPRI, 2013a), the velocity randomization procedure made use of random field models which describe the statistical correlation between layering and shear wave velocity. The default randomization parameters developed in the *Description and Validation of the Stochastic Ground Motion Model* (Toro, 1997) for United States Geological Survey (USGS) "A" site conditions were used for this site. Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 ft and 0.15 below that depth. As specified in the SPID (EPRI, 2013a), correlation of shear wave velocity between layers was modeled using the footprint correlation model. In the correlation model, a limit of ±2 standard deviations about the median value in each layer was assumed for the limits on random velocity fluctuations. (EPRI, 2014)

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID (EPRI, 2013a), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median peak ground accelerations (PGA) ranging from 0.01 to 1.5g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the PNPS site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID (EPRI, 2013a) as appropriate for typical CEUS sites. (EPRI, 2014)

2.3.5 Methodology

To perform the site response analyses for the Pilgrim site, a random vibration theory (RVT) approach was employed. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID (EPRI, 2013a). The guidance contained in Appendix B of the SPID (EPRI, 2013a) on incorporating epistemic uncertainty in shear-wave velocities, kappa, non-linear dynamic properties and source spectra for plants with limited at-site information was followed for the PNPS site. (EPRI, 2014)

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% damped pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each oscillator frequency and input rock amplitude. Consistent with the SPID (EPRI, 2013a) a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and ±1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by the median reference (hard-rock) peak acceleration (0.01g to 1.50g) for profile P1 and EPRI soil and rock G/G_{max} and hysteretic damping curves. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard-rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at the PNPS shallow soil and firm rock site, Figure 2.3.6-2 shows the corresponding amplification factors developed with Peninsular Range G/G_{max} and hysteretic damping curves for soil combined with linear analysis for firm rock (model M2). Figures 2.3.6-1 and Figure 2.3.6-2 respectively show only a minor difference for all frequencies and all loading levels. Tabular data for Figure 2.3.6-1 and Figure 2.3.6-2 is provided for information only in Appendix A. (EPRI, 2014)

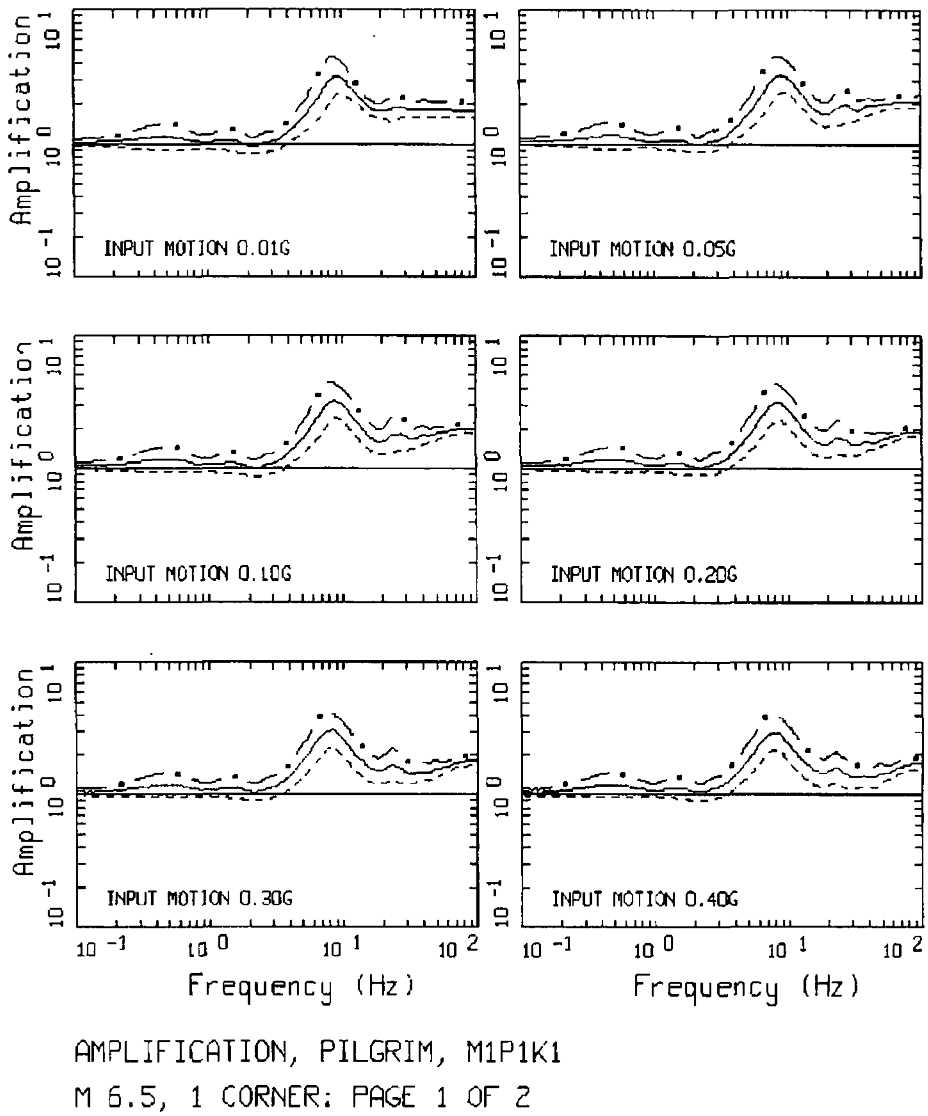
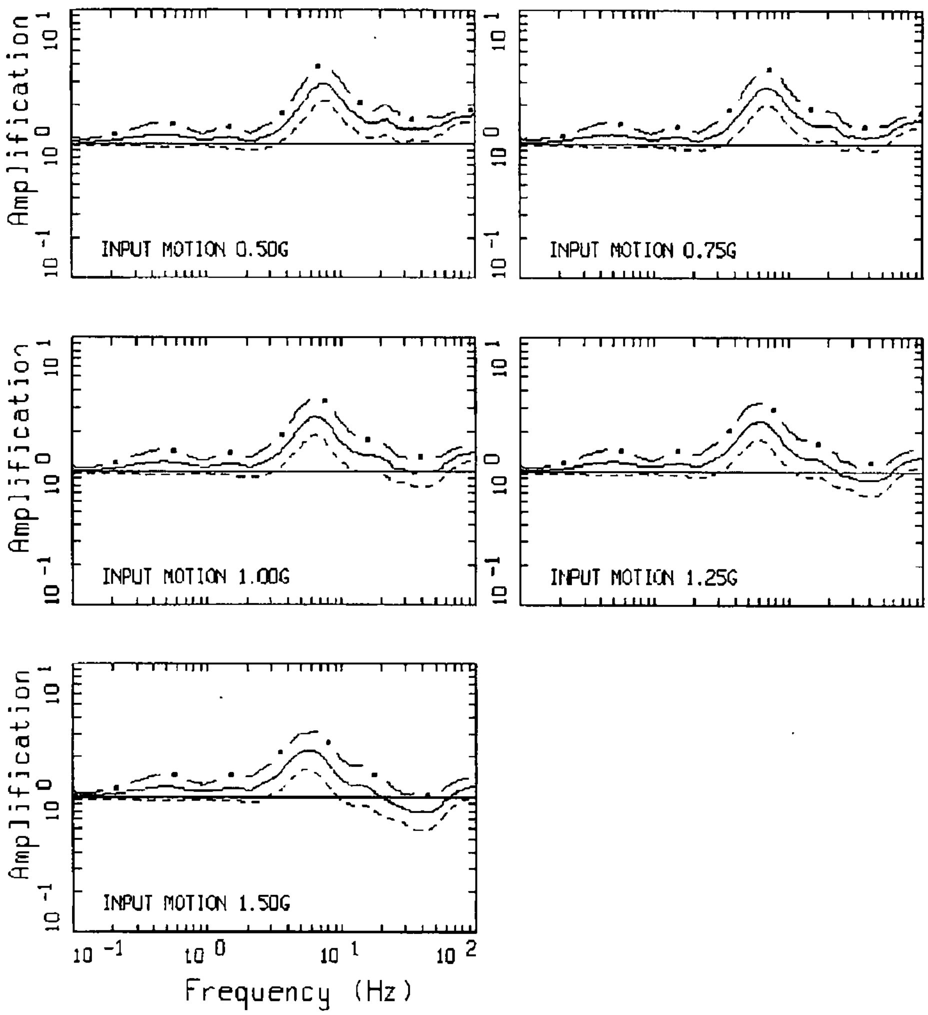


Figure 2.3.6-1.Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI soil and firm rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard-rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (EPRI, 2013a). (EPRI, 2014)



AMPLIFICATION, PILGRIM, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1.(cont.)

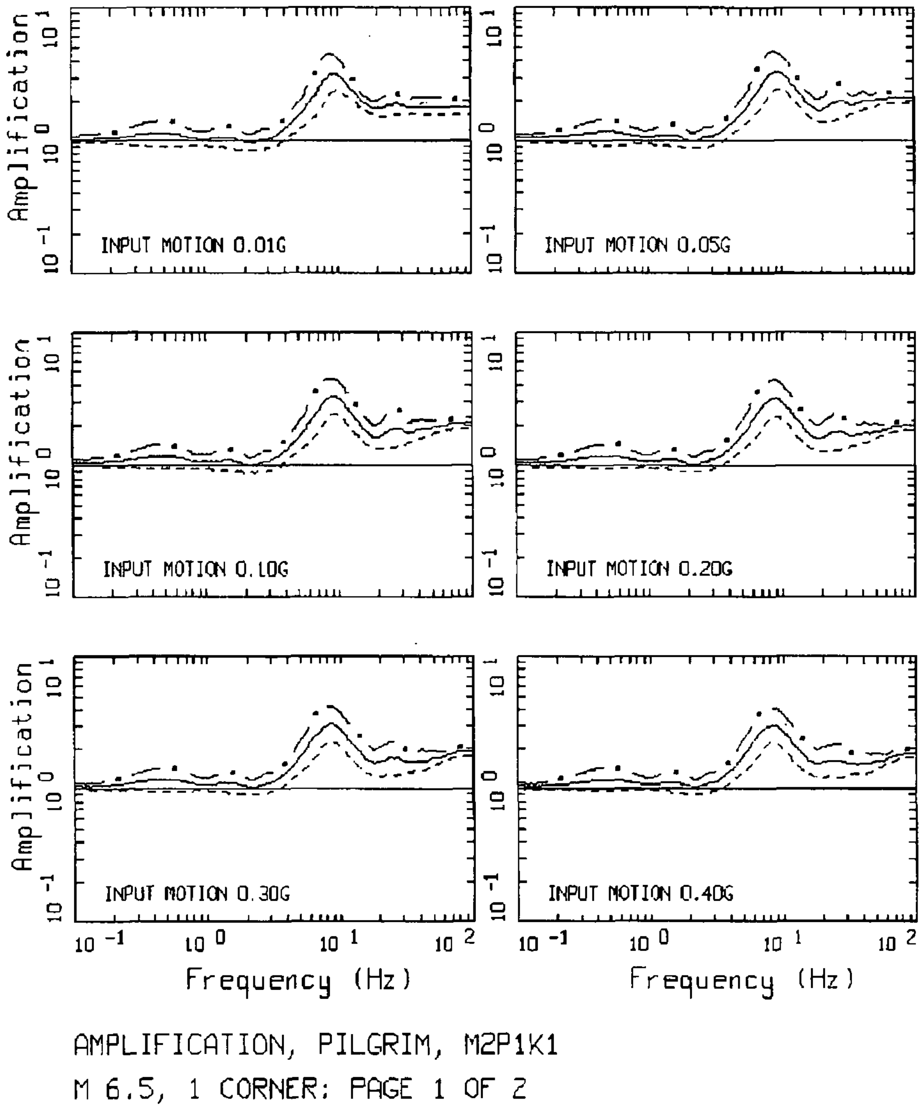
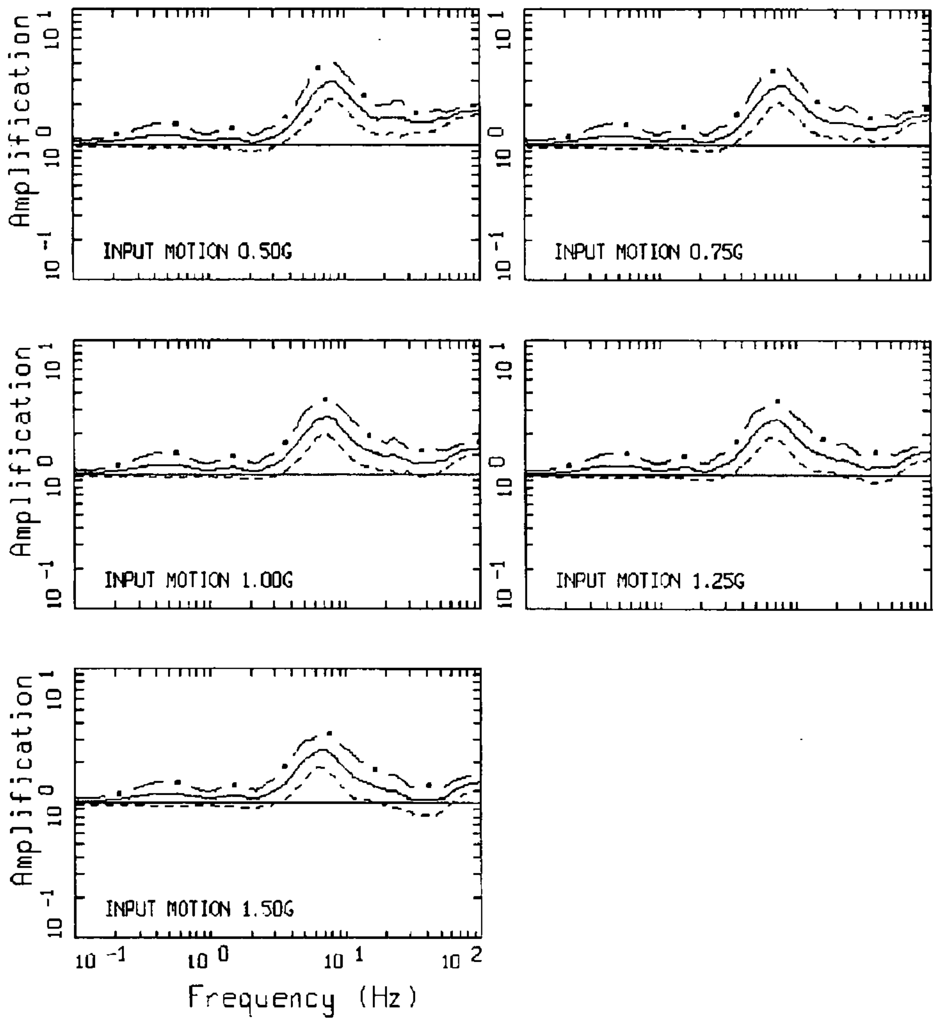


Figure 2.3.6-2. Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), Peninsular Range modulus reduction and hysteretic damping curves for soil combined with linear response for firm rock (model M2), and base-case kappa at eleven loading levels of hard-rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (EPRI, 2013a). (EPRI, 2014)



AMPLIFICATION, PILGRIM, M2P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-2.(cont.)

2.3.7 Control Point Seismic Hazard Curves

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis follows the methodology described in Section B-6.0 of the SPID (EPRI, 2013a). This procedure (referred to as Method 3) computes a site-specific control point hazard curve for a broad range of spectral accelerations given the site-specific bedrock hazard curve and site-specific estimates of soil or soft-rock response and associated uncertainties. This process is repeated for each of the seven spectral frequencies for which ground motion equations are available. The dynamic response of the materials below the control point was represented by the frequency- and amplitude-dependent amplification functions (median values and standard deviations) developed and described in the previous section. The resulting control point mean hazard curves for Pilgrim are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A. (EPRI, 2014)

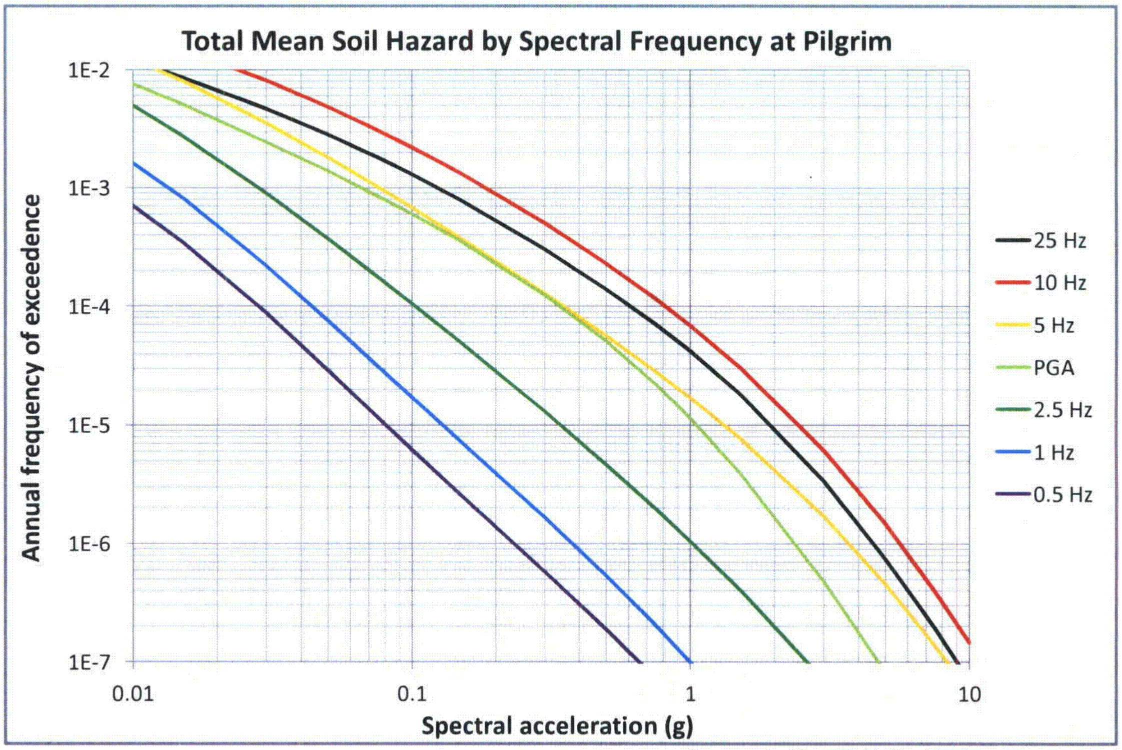


Figure 2.3.7-1. Control point mean hazard curves for spectral frequencies of 0.5, 1.0, 2.5, 5.0, 10, 25 and PGA (100 Hz) at PNPS. (EPRI, 2014)

2.4 Ground Motion Response Spectrum

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the GMRS. The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 10^{-4} and 10^{-5} per year hazard levels. Table 2.4-1 shows the UHRS and GMRS accelerations for a range of frequencies. (EPRI, 2014)

Table 2.4-1. UHRS and GMRS for PNPS. (EPRI, 2014)

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	3.40E-01	1.06E+00	5.05E-01
90	3.42E-01	1.06E+00	5.09E-01
80	3.48E-01	1.08E+00	5.18E-01
70	3.62E-01	1.13E+00	5.40E-01
60	3.98E-01	1.24E+00	5.93E-01
50	4.85E-01	1.53E+00	7.31E-01
40	5.77E-01	1.79E+00	8.57E-01
35	6.23E-01	1.92E+00	9.21E-01
30	6.26E-01	2.00E+00	9.51E-01
25	6.12E-01	1.93E+00	9.22E-01
20	5.98E-01	1.91E+00	9.09E-01
15	6.44E-01	2.01E+00	9.61E-01
12.5	7.25E-01	2.20E+00	1.06E+00
10	8.17E-01	2.44E+00	1.18E+00
9	7.91E-01	2.43E+00	1.16E+00
8	7.23E-01	2.30E+00	1.10E+00
7	6.19E-01	2.07E+00	9.75E-01
6	4.87E-01	1.73E+00	8.07E-01
5	3.51E-01	1.32E+00	6.09E-01
4	2.23E-01	8.30E-01	3.83E-01
3.5	1.75E-01	6.32E-01	2.93E-01
3	1.35E-01	4.69E-01	2.19E-01
2.5	1.03E-01	3.42E-01	1.61E-01
2	8.46E-02	2.73E-01	1.29E-01
1.5	6.75E-02	2.09E-01	1.00E-01
1.25	5.37E-02	1.63E-01	7.82E-02
1	4.37E-02	1.29E-01	6.22E-02
0.9	4.13E-02	1.21E-01	5.87E-02
0.8	3.92E-02	1.15E-01	5.55E-02
0.7	3.68E-02	1.07E-01	5.18E-02
0.6	3.34E-02	9.63E-02	4.67E-02
0.5	2.82E-02	8.07E-02	3.92E-02
0.4	2.25E-02	6.45E-02	3.14E-02
0.35	1.97E-02	5.65E-02	2.74E-02
0.3	1.69E-02	4.84E-02	2.35E-02
0.25	1.41E-02	4.03E-02	1.96E-02
0.2	1.13E-02	3.23E-02	1.57E-02
0.15	8.45E-03	2.42E-02	1.18E-02
0.125	7.04E-03	2.02E-02	9.80E-03
0.1	5.63E-03	1.61E-02	7.84E-03

The 10^{-4} and 10^{-5} UHRS are used to compute the GMRS at the control point and are shown in Figure 2.4-1. (EPRI, 2014)

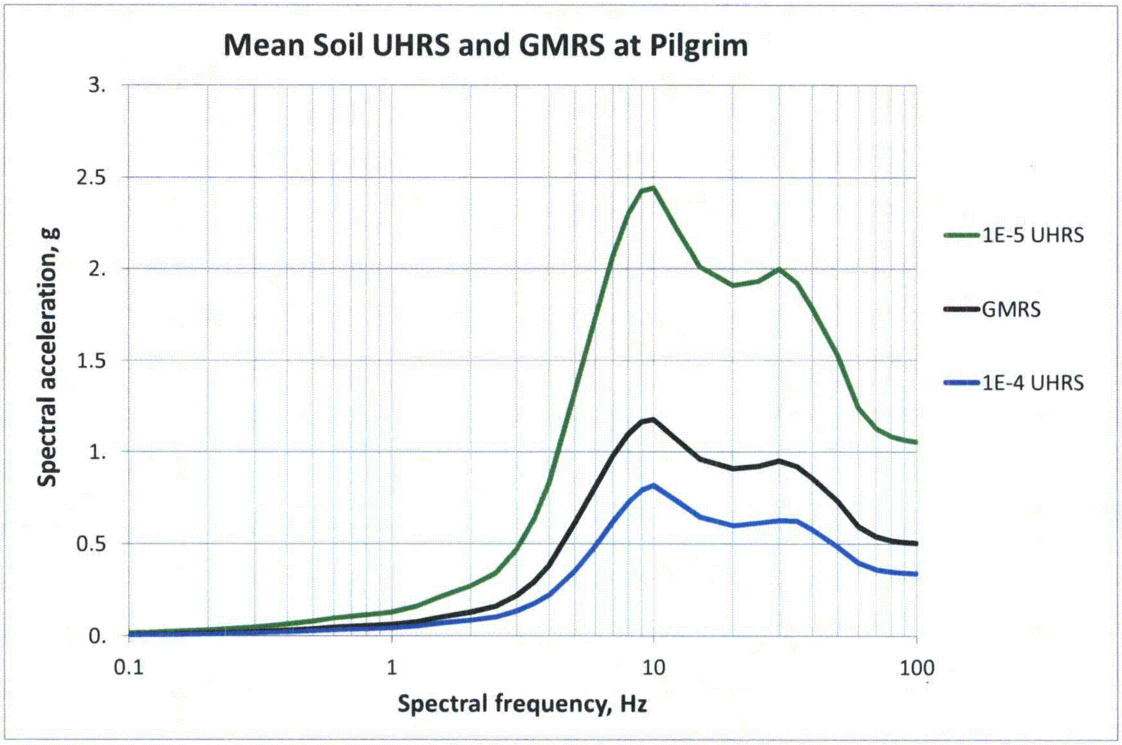


Figure 2.4-1. UHRS for 10^{-4} and 10^{-5} and GMRS at control point for PNPS. (5% damped response spectra). (EPRI, 2014)

3.0 Plant Design Basis and Beyond Design Basis Evaluation Ground Motion

The design basis for Pilgrim is identified in the Updated Final Safety Analysis Report (Entergy, 2013a).

3.1 Safe Shutdown Earthquake Description of Spectral Shape

The SSE was developed in accordance with AEC 1967 Preliminary Criterion 2 through an evaluation of the maximum earthquake potential for the region surrounding the site. Considering the historic seismicity of the site region, the maximum potential earthquake was determined to be an intensity VIII on the Modified Mercalli Intensity Scale of 1931.

The SSE is defined in the FSAR in terms of a PGA and a design response spectrum. These spectra have been digitalized and tabulated (Entergy, 2005b). Table 3.1-1 shows the spectral acceleration (SA) values as a function of frequency for the 5% damped horizontal SSE.

Table 3.1-1. SSE for PNPS. (Entergy, 2005b)

Freq. (Hz)	100	33	25	10	9	5	2.5	1	0.5
SA (g)	0.15	0.15	0.15	0.184	0.194	0.238	0.225	0.126	0.071

3.2 Control Point Elevation

The SSE control point elevation is defined at the bottom of the Reactor Building foundation at elevation -26 ft MSL which is 48 ft below grade based on section 2.5.3.3.2, section 2.5.2.4.3, and Figure 12.2-6 of the FSAR (Entergy, 2013a).

3.3 IPEEE Description and Capacity Response Spectrum

PNPS performed a Seismic Probabilistic Risk Assessment (SPRA) in conjunction with its Individual Plant Examination of External Events (IPEEE) program. Based on cursory review of the IPEEE report, the results are not sufficient to serve as the basis for PNPS to screen-out of further risk assessment. Therefore, a detailed IPEEE adequacy evaluation was not performed.

4.0 Screening Evaluation

In accordance with SPID (EPRI, 2013a) Section 3, a screening evaluation was performed as described below.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, Pilgrim screens-in for a risk evaluation.

4.2 High Frequency Screening (> 10 Hz)

In the frequency range greater than 10 Hz, the GMRS exceeds the SSE. The high frequency exceedances can be addressed in the risk evaluation discussed in 4.1 above.

4.3 Spent Fuel Pool Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, Pilgrim screens-in for a Spent Fuel Pool evaluation.

5.0 Interim Actions

Based on the screening evaluation, the expedited seismic evaluation described in EPRI 3002000704 (EPRI, 2013c) will be performed as proposed in a letter to NRC (ML131 01A379) dated April 9, 2013 (NEI, 2013) and agreed to by NRC (ML13106A331) in a letter dated May 7, 2013 (U.S. NRC, 2013)

Consistent with NRC letter (ML14030A046) dated February 20, 2014, (U.S. NRC, 2014) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of PNPS. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to 10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and 10 CFR 50.73, "Licensee event report system".

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, NEI letter dated March 12, 2014 (NEI, 2014), provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the Central and Eastern United States. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment (U.S. NRC, 2010):

> Overall seismic core damage risk estimates are consistent with the Commission's Safety Goal Policy Statement because they are within the subsidiary objective of 10^{-4}/year for core damage frequency. The GI-199 Safety/Risk Assessment, based in part on information from the U.S. NRC's Individual Plant Examination of External Events (IPEEE) program, indicates that no concern exists regarding adequate protection and that the current seismic design of operating reactors provides a safety margin to withstand potential earthquakes exceeding the original design basis.

PNPS is included in the March 12, 2014 risk estimates (NEI, 2014). Using the methodology described in the NEI letter, all plants were shown to be below 10^{-4}/year; thus, the above conclusions apply.

PNPS completed its Fukushima 50.54(f) Seismic 2.3 Walkdown Program in 2013 and submitted the associated final report to NRC. (Entergy, 2013b) Based on this effort, PNPS has concluded that the plant modifications originating from the IPEEE program were fully implemented and that the facility has been maintained within its seismic design basis since completion of IPEEE and A-46 programs. The walkdown program identified a total of 17 potentially adverse seismic conditions. These were generally considered to be minor housekeeping type issues. All issues have since been resolved via the Licensing Basis Evaluation (LBE) process or physically corrected in accordance with PNPS' corrective action and work control processes. No plant modifications resulted from the Seismic 2.3 walkdown program.

In conjunction with Generic Issue GI-199, NRC performed a Safety/Risk Assessment of US Nuclear Plant Seismic Core Damage Frequencies. NRC used the 2008 US Geological Survey (USGS) Seismic Hazard Curves and existing PNPS Individual Plant Examination of External Events (IPEEE) information to perform the risk assessment. The report identified

PNPS as having relatively high calculated Seismic Core Damage Frequency (SCDF), although within the acceptable range. Since the original PNPS IPEEE work was known to include conservatisms, Entergy assembled a Seismic Review Team (SRT) which was tasked with developing a SCDF estimate that more closely reflected the robustness of the PNPS facility.

The plant level High Confidence of a Low Probability of Failure (HCLPF) spectrum peak ground acceleration developed in the original IPEEE was calculated in a very conservative manner (Entergy, 1994). When using the resulting capacity estimates in conjunction with the USGS seismic hazard curves, the NRC determined a very conservative SCDF estimate of 6.9E-05 per year, or 1 in 14,493 reactor-years for PNPS. Using the improved plant capacities developed by the SRT, a reassessment of the SCDF estimate was performed. This resulted in a SCDF of 3.98E-05 per year, or 1 in 25,126 reactor-years using the same USGS hazard curves. With the use of the improved plant capacity and EPRI updated 2010 hazard curves, the SCDF estimate is further reduced to 1.46E-05 per year (or 1 in 68,493 reactor-years) for PNPS. In conclusion, the SRT has demonstrated a larger plant-level seismic capacity than that used in the NRC assessment for PNPS. (Entergy, 2011)

6.0 Conclusions

In accordance with the 50.54(f) request for information (U.S. NRC, 2012), a seismic hazard and screening evaluation was performed for PNPS. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID (EPRI, 2013a). Based on the results of the screening evaluation, PNPS screens-in for a risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency Confirmation.

7.0 References

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10 CFR Part 100. Title 10, Code of Federal Regulations, Part 100, "Reactor Site Criteria," U.S. Nuclear Regulatory Commission, Washington DC.

10 CFR Part 50.72. Title 10, Code of Federal Regulations, Part 50.72, "Immediate Notification Requirements for Operating Nuclear Power Reactors," U.S. Nuclear Regulatory Commission, Washington DC.

10 CFR Part 50.73. Title 10, Code of Federal Regulations, Part 50.73, "Licensee Event Report System," U.S. Nuclear Regulatory Commission, Washington DC.

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Appendix A

Tabulated Data

Table A-1a. Mean and Fractile Seismic Hazard Curves for PGA at PNPS.
(EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.13E-02	2.72E-02	4.07E-02	5.12E-02	6.36E-02	7.03E-02
0.001	4.08E-02	1.82E-02	3.01E-02	4.07E-02	5.27E-02	6.09E-02
0.005	1.42E-02	5.83E-03	9.37E-03	1.32E-02	1.90E-02	2.60E-02
0.01	7.61E-03	3.19E-03	4.56E-03	6.93E-03	9.79E-03	1.60E-02
0.015	5.12E-03	2.10E-03	2.92E-03	4.56E-03	6.54E-03	1.16E-02
0.03	2.47E-03	8.72E-04	1.27E-03	2.07E-03	3.28E-03	6.54E-03
0.05	1.39E-03	4.01E-04	6.26E-04	1.08E-03	1.95E-03	4.07E-03
0.075	8.57E-04	2.04E-04	3.33E-04	6.36E-04	1.29E-03	2.72E-03
0.1	5.99E-04	1.25E-04	2.10E-04	4.25E-04	9.24E-04	1.95E-03
0.15	3.50E-04	6.17E-05	1.07E-04	2.39E-04	5.58E-04	1.18E-03
0.3	1.24E-04	1.90E-05	3.33E-05	8.23E-05	2.01E-04	3.95E-04
0.5	5.08E-05	7.23E-06	1.27E-05	3.37E-05	8.23E-05	1.51E-04
0.75	2.23E-05	2.92E-06	5.42E-06	1.46E-05	3.68E-05	6.73E-05
1.	1.15E-05	1.36E-06	2.60E-06	7.23E-06	1.95E-05	3.63E-05
1.5	4.00E-06	3.52E-07	7.55E-07	2.32E-06	6.83E-06	1.32E-05
3.	4.82E-07	1.55E-08	4.70E-08	2.13E-07	8.00E-07	1.82E-06
5.	8.24E-08	7.23E-10	3.23E-09	2.46E-08	1.29E-07	3.52E-07
7.5	1.79E-08	8.72E-11	3.09E-10	3.47E-09	2.49E-08	8.23E-08
10.	5.57E-09	3.79E-11	8.85E-11	7.89E-10	6.93E-09	2.68E-08

Table A-1b. Mean and Fractile Seismic Hazard Curves for 25 Hz at PNPS. (EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.51E-02	3.63E-02	4.56E-02	5.42E-02	6.64E-02	7.23E-02
0.001	4.67E-02	2.57E-02	3.68E-02	4.63E-02	5.75E-02	6.54E-02
0.005	2.02E-02	9.37E-03	1.42E-02	1.90E-02	2.60E-02	3.47E-02
0.01	1.20E-02	5.58E-03	7.89E-03	1.11E-02	1.53E-02	2.32E-02
0.015	8.67E-03	4.07E-03	5.50E-03	8.00E-03	1.08E-02	1.77E-02
0.03	4.72E-03	2.10E-03	2.84E-03	4.31E-03	5.91E-03	1.04E-02
0.05	2.86E-03	1.16E-03	1.64E-03	2.57E-03	3.68E-03	6.45E-03
0.075	1.84E-03	6.73E-04	9.79E-04	1.60E-03	2.46E-03	4.31E-03
0.1	1.31E-03	4.37E-04	6.54E-04	1.13E-03	1.82E-03	3.14E-03
0.15	7.86E-04	2.25E-04	3.57E-04	6.54E-04	1.15E-03	1.95E-03
0.3	3.03E-04	6.64E-05	1.13E-04	2.42E-04	4.70E-04	7.77E-04
0.5	1.40E-04	2.72E-05	4.77E-05	1.10E-04	2.25E-04	3.57E-04
0.75	7.14E-05	1.32E-05	2.32E-05	5.58E-05	1.16E-04	1.84E-04
1.	4.23E-05	7.55E-06	1.34E-05	3.28E-05	7.03E-05	1.10E-04
1.5	1.86E-05	3.14E-06	5.66E-06	1.40E-05	3.19E-05	4.98E-05
3.	3.40E-06	4.25E-07	8.35E-07	2.29E-06	5.83E-06	1.01E-05
5.	7.47E-07	5.66E-08	1.25E-07	4.25E-07	1.32E-06	2.57E-06
7.5	1.95E-07	7.55E-09	1.98E-08	8.85E-08	3.47E-07	7.34E-07
10.	7.03E-08	1.44E-09	4.43E-09	2.64E-08	1.21E-07	2.88E-07

Table A-1c. Mean and Fractile Seismic Hazard Curves for 10 Hz at PNPS.
(EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	6.04E-02	4.77E-02	5.12E-02	5.91E-02	7.03E-02	7.66E-02
0.001	5.65E-02	4.25E-02	4.70E-02	5.50E-02	6.73E-02	7.34E-02
0.005	3.25E-02	1.87E-02	2.46E-02	3.19E-02	4.07E-02	4.77E-02
0.01	2.07E-02	1.10E-02	1.49E-02	1.98E-02	2.64E-02	3.28E-02
0.015	1.51E-02	7.77E-03	1.05E-02	1.44E-02	1.95E-02	2.46E-02
0.03	8.15E-03	4.07E-03	5.35E-03	7.77E-03	1.05E-02	1.44E-02
0.05	4.87E-03	2.32E-03	3.09E-03	4.56E-03	6.26E-03	9.11E-03
0.075	3.12E-03	1.40E-03	1.90E-03	2.88E-03	4.07E-03	6.09E-03
0.1	2.22E-03	9.37E-04	1.31E-03	2.04E-03	2.96E-03	4.43E-03
0.15	1.33E-03	4.98E-04	7.34E-04	1.20E-03	1.84E-03	2.76E-03
0.3	5.07E-04	1.46E-04	2.29E-04	4.37E-04	7.55E-04	1.13E-03
0.5	2.30E-04	5.35E-05	8.98E-05	1.90E-04	3.63E-04	5.50E-04
0.75	1.17E-04	2.32E-05	4.01E-05	9.37E-05	1.90E-04	2.88E-04
1.	6.93E-05	1.25E-05	2.22E-05	5.42E-05	1.15E-04	1.79E-04
1.5	3.11E-05	4.98E-06	8.98E-06	2.32E-05	5.27E-05	8.47E-05
3.	6.21E-06	7.13E-07	1.42E-06	4.13E-06	1.08E-05	1.87E-05
5.	1.48E-06	1.13E-07	2.53E-07	8.60E-07	2.64E-06	4.98E-06
7.5	4.02E-07	1.98E-08	4.98E-08	2.01E-07	7.13E-07	1.49E-06
10.	1.47E-07	4.77E-09	1.40E-08	6.45E-08	2.53E-07	5.66E-07

Table A-1d. Mean and Fractile Seismic Hazard Curves for 5.0 Hz at PNPS.
(EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.74E-02	4.31E-02	4.77E-02	5.58E-02	6.83E-02	7.45E-02
0.001	5.02E-02	3.33E-02	3.95E-02	4.98E-02	6.17E-02	6.83E-02
0.005	2.24E-02	1.08E-02	1.44E-02	2.16E-02	3.05E-02	3.68E-02
0.01	1.23E-02	5.42E-03	7.45E-03	1.16E-02	1.72E-02	2.16E-02
0.015	8.13E-03	3.42E-03	4.83E-03	7.66E-03	1.15E-02	1.46E-02
0.03	3.59E-03	1.42E-03	2.04E-03	3.33E-03	5.12E-03	6.73E-03
0.05	1.83E-03	6.54E-04	9.79E-04	1.67E-03	2.68E-03	3.63E-03
0.075	1.03E-03	3.28E-04	5.12E-04	9.24E-04	1.53E-03	2.13E-03
0.1	6.82E-04	1.98E-04	3.14E-04	6.00E-04	1.04E-03	1.44E-03
0.15	3.74E-04	9.24E-05	1.55E-04	3.19E-04	5.91E-04	8.47E-04
0.3	1.29E-04	2.39E-05	4.31E-05	1.01E-04	2.16E-04	3.28E-04
0.5	5.66E-05	8.85E-06	1.64E-05	4.25E-05	9.79E-05	1.53E-04
0.75	2.85E-05	4.01E-06	7.66E-06	2.07E-05	4.90E-05	7.89E-05
1.	1.71E-05	2.22E-06	4.37E-06	1.20E-05	2.96E-05	4.90E-05
1.5	7.87E-06	9.24E-07	1.87E-06	5.35E-06	1.38E-05	2.35E-05
3.	1.72E-06	1.67E-07	3.57E-07	1.08E-06	3.01E-06	5.42E-06
5.	4.60E-07	3.68E-08	8.35E-08	2.72E-07	7.89E-07	1.53E-06
7.5	1.41E-07	9.11E-09	2.19E-08	7.55E-08	2.42E-07	4.98E-07
10.	5.65E-08	2.96E-09	7.45E-09	2.80E-08	9.51E-08	2.07E-07

Table A-1e. Mean and Fractile Seismic Hazard Curves for 2.5 Hz at PNPS.
(EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.09E-02	3.52E-02	4.01E-02	5.05E-02	6.17E-02	6.93E-02
0.001	3.93E-02	2.32E-02	2.84E-02	3.90E-02	5.05E-02	5.83E-02
0.005	1.15E-02	5.42E-03	7.45E-03	1.08E-02	1.57E-02	1.92E-02
0.01	4.98E-03	2.22E-03	3.09E-03	4.63E-03	6.93E-03	8.85E-03
0.015	2.79E-03	1.20E-03	1.64E-03	2.60E-03	3.90E-03	5.20E-03
0.03	9.03E-04	3.42E-04	4.90E-04	8.23E-04	1.29E-03	1.82E-03
0.05	3.68E-04	1.20E-04	1.82E-04	3.28E-04	5.50E-04	7.77E-04
0.075	1.77E-04	4.83E-05	7.77E-05	1.51E-04	2.72E-04	3.95E-04
0.1	1.05E-04	2.49E-05	4.13E-05	8.72E-05	1.64E-04	2.49E-04
0.15	4.94E-05	9.65E-06	1.69E-05	3.90E-05	8.00E-05	1.27E-04
0.3	1.30E-05	1.79E-06	3.47E-06	9.24E-06	2.22E-05	3.79E-05
0.5	4.65E-06	4.70E-07	9.93E-07	2.96E-06	8.12E-06	1.46E-05
0.75	1.97E-06	1.42E-07	3.42E-07	1.13E-06	3.42E-06	6.64E-06
1.	1.05E-06	5.75E-08	1.51E-07	5.58E-07	1.82E-06	3.73E-06
1.5	4.11E-07	1.36E-08	4.13E-08	1.87E-07	7.23E-07	1.57E-06
3.	7.12E-08	7.89E-10	3.09E-09	2.22E-08	1.18E-07	3.05E-07
5.	1.65E-08	1.10E-10	3.68E-10	3.42E-09	2.49E-08	7.45E-08
7.5	4.50E-09	4.90E-11	9.37E-11	6.93E-10	6.17E-09	2.10E-08
10.	1.65E-09	3.01E-11	8.12E-11	2.22E-10	2.07E-09	7.66E-09

Table A-1f. Mean and Fractile Seismic Hazard Curves for 1.0 Hz at PNPS. (EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.31E-02	1.53E-02	2.19E-02	3.28E-02	4.37E-02	5.12E-02
0.001	2.10E-02	8.60E-03	1.34E-02	2.07E-02	2.88E-02	3.47E-02
0.005	4.28E-03	1.36E-03	2.32E-03	3.90E-03	6.26E-03	8.60E-03
0.01	1.62E-03	4.25E-04	7.66E-04	1.40E-03	2.46E-03	3.63E-03
0.015	8.24E-04	1.95E-04	3.52E-04	6.83E-04	1.29E-03	1.98E-03
0.03	2.19E-04	4.25E-05	7.66E-05	1.67E-04	3.63E-04	5.66E-04
0.05	7.52E-05	1.18E-05	2.22E-05	5.35E-05	1.31E-04	2.04E-04
0.075	3.16E-05	4.01E-06	8.00E-06	2.07E-05	5.50E-05	9.24E-05
0.1	1.71E-05	1.82E-06	3.79E-06	1.05E-05	2.92E-05	5.35E-05
0.15	7.24E-06	5.83E-07	1.31E-06	4.07E-06	1.21E-05	2.49E-05
0.3	1.66E-06	6.93E-08	1.92E-07	7.34E-07	2.80E-06	6.54E-06
0.5	5.34E-07	1.15E-08	3.90E-08	1.92E-07	8.85E-07	2.29E-06
0.75	2.04E-07	2.29E-09	9.51E-09	5.91E-08	3.19E-07	9.37E-07
1.	9.89E-08	6.93E-10	3.09E-09	2.32E-08	1.49E-07	4.70E-07
1.5	3.29E-08	1.44E-10	5.91E-10	5.42E-09	4.37E-08	1.60E-07
3.	3.89E-09	3.14E-11	8.12E-11	3.28E-10	3.79E-09	1.82E-08
5.	6.38E-10	2.01E-11	3.01E-11	8.12E-11	4.83E-10	2.68E-09
7.5	1.29E-10	2.01E-11	3.01E-11	8.12E-11	1.18E-10	5.20E-10
10.	3.81E-11	2.01E-11	3.01E-11	8.12E-11	8.12E-11	1.74E-10

Table A-1g. Mean and Fractile Seismic Hazard Curves for 0.5 Hz at PNPS.
(EPRI, 2014)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.83E-02	8.72E-03	1.29E-02	1.77E-02	2.39E-02	2.92E-02
0.001	1.06E-02	4.50E-03	7.03E-03	9.93E-03	1.42E-02	1.87E-02
0.005	1.95E-03	4.70E-04	9.11E-04	1.64E-03	3.05E-03	4.43E-03
0.01	7.03E-04	1.21E-04	2.49E-04	5.35E-04	1.20E-03	1.84E-03
0.015	3.48E-04	4.98E-05	1.02E-04	2.42E-04	6.09E-04	9.79E-04
0.03	8.81E-05	8.85E-06	1.87E-05	5.20E-05	1.64E-04	2.76E-04
0.05	2.90E-05	2.16E-06	4.90E-06	1.51E-05	5.42E-05	9.93E-05
0.075	1.17E-05	6.64E-07	1.60E-06	5.35E-06	2.16E-05	4.50E-05
0.1	6.22E-06	2.80E-07	7.13E-07	2.57E-06	1.08E-05	2.60E-05
0.15	2.57E-06	7.66E-08	2.16E-07	9.11E-07	4.13E-06	1.21E-05
0.3	5.82E-07	6.26E-09	2.49E-08	1.40E-07	8.12E-07	3.05E-06
0.5	1.88E-07	7.89E-10	4.19E-09	3.09E-08	2.25E-07	1.04E-06
0.75	7.35E-08	1.64E-10	8.98E-10	8.12E-09	7.45E-08	4.01E-07
1.	3.64E-08	8.35E-11	2.92E-10	2.88E-09	3.14E-08	1.95E-07
1.5	1.27E-08	4.83E-11	8.98E-11	6.17E-10	8.35E-09	6.36E-08
3.	1.68E-09	2.01E-11	3.01E-11	8.12E-11	6.54E-10	7.03E-09
5.	3.08E-10	2.01E-11	3.01E-11	8.12E-11	1.20E-10	1.10E-09
7.5	6.95E-11	2.01E-11	3.01E-11	8.12E-11	8.12E-11	2.42E-10
10.	2.22E-11	2.01E-11	3.01E-11	8.12E-11	8.12E-11	1.07E-10

Table A-2. Amplification Functions for PNPS. (EPRI, 2014)

PGA	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)	5 Hz	Median AF	Sigma ln(AF)
1.00E-02	1.98E+00	1.51E-01	1.30E-02	1.96E+00	1.89E-01	1.90E-02	2.93E+00	2.86E-01	2.09E-02	1.63E+00	3.00E-01
4.95E-02	2.18E+00	1.05E-01	1.02E-01	1.85E+00	2.71E-01	9.99E-02	2.92E+00	2.97E-01	8.24E-02	1.76E+00	3.24E-01
9.64E-02	2.12E+00	9.73E-02	2.13E-01	1.77E+00	2.80E-01	1.85E-01	2.82E+00	3.01E-01	1.44E-01	1.82E+00	3.42E-01
1.94E-01	2.00E+00	9.91E-02	4.43E-01	1.66E+00	2.74E-01	3.56E-01	2.66E+00	3.07E-01	2.65E-01	1.89E+00	3.54E-01
2.92E-01	1.91E+00	1.04E-01	6.76E-01	1.58E+00	2.66E-01	5.23E-01	2.54E+00	3.11E-01	3.84E-01	1.95E+00	3.48E-01
3.91E-01	1.83E+00	1.11E-01	9.09E-01	1.51E+00	2.60E-01	6.90E-01	2.42E+00	3.13E-01	5.02E-01	1.99E+00	3.33E-01
4.93E-01	1.75E+00	1.20E-01	1.15E+00	1.45E+00	2.59E-01	8.61E-01	2.32E+00	3.18E-01	6.22E-01	2.01E+00	3.19E-01
7.41E-01	1.62E+00	1.35E-01	1.73E+00	1.32E+00	2.56E-01	1.27E+00	2.11E+00	3.24E-01	9.13E-01	2.04E+00	3.15E-01
1.01E+00	1.51E+00	1.50E-01	2.36E+00	1.23E+00	2.60E-01	1.72E+00	1.94E+00	3.28E-01	1.22E+00	2.05E+00	3.21E-01
1.28E+00	1.41E+00	1.62E-01	3.01E+00	1.14E+00	2.70E-01	2.17E+00	1.79E+00	3.35E-01	1.54E+00	2.04E+00	3.28E-01
1.55E+00	1.33E+00	1.74E-01	3.63E+00	1.07E+00	2.80E-01	2.61E+00	1.67E+00	3.48E-01	1.85E+00	2.01E+00	3.32E-01
2.5 Hz	**Median AF**	**Sigma ln(AF)**	**1 Hz**	**Median AF**	**Sigma ln(AF)**	**0.5 Hz**	**Median AF**	**Sigma ln(AF)**			
2.18E-02	1.04E+00	1.58E-01	1.27E-02	1.06E+00	1.06E-01	8.25E-03	1.20E+00	2.13E-01			
7.05E-02	1.07E+00	1.58E-01	3.43E-02	1.08E+00	1.04E-01	1.96E-02	1.22E+00	2.09E-01			
1.18E-01	1.09E+00	1.59E-01	5.51E-02	1.09E+00	1.04E-01	3.02E-02	1.22E+00	2.08E-01			
2.12E-01	1.10E+00	1.62E-01	9.63E-02	1.09E+00	1.04E-01	5.11E-02	1.23E+00	2.07E-01			
3.04E-01	1.12E+00	1.66E-01	1.36E-01	1.10E+00	1.05E-01	7.10E-02	1.23E+00	2.07E-01			
3.94E-01	1.13E+00	1.70E-01	1.75E-01	1.10E+00	1.06E-01	9.06E-02	1.23E+00	2.08E-01			
4.86E-01	1.14E+00	1.77E-01	2.14E-01	1.10E+00	1.07E-01	1.10E-01	1.23E+00	2.08E-01			
7.09E-01	1.17E+00	1.94E-01	3.10E-01	1.11E+00	1.10E-01	1.58E-01	1.23E+00	2.08E-01			
9.47E-01	1.21E+00	2.20E-01	4.12E-01	1.11E+00	1.11E-01	2.09E-01	1.23E+00	2.08E-01			
1.19E+00	1.24E+00	2.52E-01	5.18E-01	1.11E+00	1.12E-01	2.62E-01	1.23E+00	2.09E-01			
1.43E+00	1.27E+00	2.66E-01	6.19E-01	1.12E+00	1.14E-01	3.12E-01	1.23E+00	2.09E-01			

Tables A-3a and A-3b are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 10^{-4} and 10^{-5} mean annual frequency of exceedance. These factors are unverified and are provided for information only. The figures should be considered the governing information.

Table A-3a. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels.

For Information Only

M1P1K1	Rock PGA=0.194			M1P1K1	PGA=0.741		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.370	1.910	0.081	100.0	1.121	1.514	0.114
87.1	0.377	1.895	0.081	87.1	1.139	1.489	0.117
75.9	0.389	1.867	0.080	75.9	1.170	1.445	0.123
66.1	0.411	1.810	0.081	66.1	1.230	1.361	0.133
57.5	0.456	1.720	0.082	57.5	1.344	1.234	0.153
50.1	0.535	1.677	0.125	50.1	1.554	1.170	0.186
43.7	0.600	1.594	0.140	43.7	1.787	1.138	0.226
38.0	0.667	1.608	0.165	38.0	1.899	1.115	0.208
33.1	0.672	1.530	0.186	33.1	2.005	1.131	0.185
28.8	0.707	1.608	0.241	28.8	2.011	1.152	0.199
25.1	0.752	1.697	0.285	25.1	2.071	1.195	0.242
21.9	0.708	1.677	0.280	21.9	2.211	1.361	0.245
19.1	0.643	1.542	0.227	19.1	2.206	1.397	0.254
16.6	0.641	1.599	0.243	16.6	2.062	1.377	0.261
14.5	0.683	1.782	0.246	14.5	2.010	1.423	0.282
12.6	0.771	2.067	0.265	12.6	2.077	1.527	0.286
11.0	0.901	2.477	0.288	11.0	2.259	1.720	0.309
9.5	1.014	2.916	0.289	9.5	2.536	2.041	0.334
8.3	1.010	3.146	0.301	8.3	2.797	2.463	0.335
7.2	0.881	2.930	0.363	7.2	2.838	2.690	0.303
6.3	0.692	2.448	0.359	6.3	2.594	2.637	0.312
5.5	0.537	1.989	0.317	5.5	2.165	2.321	0.329
4.8	0.437	1.654	0.288	4.8	1.748	1.928	0.321
4.2	0.366	1.428	0.229	4.2	1.425	1.631	0.275
3.6	0.312	1.253	0.205	3.6	1.180	1.395	0.262
3.2	0.268	1.141	0.188	3.2	0.982	1.240	0.235
2.8	0.245	1.098	0.185	2.8	0.874	1.168	0.212
2.4	0.215	1.045	0.151	2.4	0.752	1.095	0.176
2.1	0.192	1.027	0.134	2.1	0.662	1.065	0.151
1.8	0.178	1.066	0.164	1.8	0.606	1.095	0.172
1.6	0.160	1.105	0.188	1.6	0.539	1.128	0.192
1.4	0.138	1.107	0.171	1.4	0.460	1.126	0.177
1.2	0.120	1.092	0.151	1.2	0.396	1.107	0.155
1.0	0.107	1.077	0.122	1.0	0.350	1.090	0.125
0.91	0.097	1.076	0.108	0.91	0.315	1.087	0.110
0.79	0.090	1.096	0.134	0.79	0.288	1.106	0.134
0.69	0.082	1.126	0.168	0.69	0.261	1.135	0.168
0.60	0.073	1.155	0.196	0.60	0.231	1.163	0.196
0.52	0.063	1.172	0.212	0.52	0.198	1.179	0.212
0.46	0.053	1.173	0.214	0.46	0.165	1.180	0.214
0.10	0.002	1.056	0.061	0.10	0.006	1.049	0.059

Table A-3b. Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels.

For Information Only

M2P1K1	PGA=0.194			M2P1K1	PGA=0.741		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.387	1.995	0.080	100.0	1.242	1.678	0.091
87.1	0.394	1.983	0.079	87.1	1.266	1.655	0.094
75.9	0.408	1.959	0.077	75.9	1.310	1.617	0.099
66.1	0.433	1.910	0.078	66.1	1.394	1.542	0.111
57.5	0.487	1.835	0.080	57.5	1.550	1.423	0.126
50.1	0.575	1.804	0.123	50.1	1.855	1.396	0.171
43.7	0.655	1.737	0.155	43.7	2.116	1.347	0.200
38.0	0.704	1.697	0.158	38.0	2.269	1.333	0.204
33.1	0.730	1.663	0.181	33.1	2.347	1.324	0.179
28.8	0.774	1.760	0.285	28.8	2.443	1.399	0.222
25.1	0.782	1.765	0.315	25.1	2.475	1.427	0.290
21.9	0.718	1.700	0.286	21.9	2.386	1.468	0.240
19.1	0.666	1.596	0.230	19.1	2.306	1.460	0.240
16.6	0.666	1.662	0.227	16.6	2.245	1.499	0.253
14.5	0.723	1.888	0.252	14.5	2.252	1.594	0.275
12.6	0.828	2.220	0.274	12.6	2.412	1.773	0.312
11.0	0.966	2.654	0.282	11.0	2.688	2.047	0.327
9.5	1.066	3.067	0.299	9.5	2.995	2.410	0.333
8.3	1.017	3.170	0.316	8.3	3.132	2.758	0.330
7.2	0.858	2.854	0.370	7.2	2.889	2.738	0.287
6.3	0.670	2.370	0.368	6.3	2.482	2.522	0.324
5.5	0.518	1.919	0.299	5.5	2.021	2.166	0.350
4.8	0.423	1.602	0.256	4.8	1.623	1.790	0.322
4.2	0.357	1.394	0.201	4.2	1.327	1.518	0.247
3.6	0.307	1.231	0.187	3.6	1.109	1.312	0.217
3.2	0.265	1.127	0.172	3.2	0.936	1.182	0.188
2.8	0.243	1.088	0.177	2.8	0.843	1.127	0.186
2.4	0.214	1.038	0.141	2.4	0.733	1.067	0.146
2.1	0.191	1.022	0.127	2.1	0.649	1.044	0.130
1.8	0.178	1.062	0.161	1.8	0.597	1.079	0.162
1.6	0.160	1.102	0.184	1.6	0.533	1.116	0.184
1.4	0.138	1.105	0.167	1.4	0.456	1.117	0.166
1.2	0.120	1.090	0.147	1.2	0.394	1.100	0.147
1.0	0.107	1.076	0.119	1.0	0.348	1.084	0.119
0.91	0.097	1.075	0.106	0.91	0.314	1.083	0.106
0.79	0.090	1.095	0.131	0.79	0.287	1.102	0.131
0.69	0.082	1.125	0.165	0.69	0.260	1.132	0.164
0.60	0.073	1.154	0.194	0.60	0.231	1.160	0.192
0.52	0.063	1.171	0.209	0.52	0.198	1.176	0.207
0.46	0.053	1.173	0.211	0.46	0.164	1.178	0.209
0.10	0.002	1.056	0.059	0.10	0.006	1.048	0.056